AD 264 265

Report No.

L0414-01-10

Aerojet-General CORPORATION

AZUSA, CALIFORNIA

INFORMAL REPORT OF PROGRESS

Copy No.

21 September 1961

TO: Commanding General
Frankford Arsenal
Philadelphia 37, Pennsylvania

Attn: ORDBA, Dr. H. Gisser

SUBJECT: Investigation of Stress-Corrosion Cracking of High-Strength Alloys

CONTRACT: DA-[illegible]-ORD-3069

PERIOD COVERED: 1 August through 31 August 1961

This is the tenth in a series of informal progress reports submitted in partial fulfillment of the contract.

AEROJET-GENERAL CORPORATION

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NOTE: The information contained herein is regarded as preliminary and subject to further checking, verification, and analysis.

I. OBJECTIVES

The objectives of this program are:

A. To study the susceptibility to stress-corrosion cracking of rocket-motor case materials: e.g., Vascojet 1000, Type 300M, and Ladish D6AC steels, AM355 and PH 15-7 Mo stainless steels, and B120VCA titanium

B. To study the environmental parameters, including the atmosphere outside and inside the rocket case, that affect the rate and extent of stress corrosion

C. To determine the effect of material parameters - composition, strength level, welding, micro-structure, surface conditions, etc. - on the stress-corrosion process

D. To devise and evaluate techniques for preventing the stress-corrosion cracking of rocket-motor case materials.

II. WORK PROGRESS

A. BENT-BEAM SPECIMENS

A summary of all the environmental bent-beam stress-corrosion test data compiled to date is given in Table 1. These results reflect both completed tests and tests that are currently in progress. Six alloys are being evaluated in ten different environments. Specimens of Ladish D6AC, Type 300M, and Vascojet 1000 alloy steels, AM355 and PH 15-7 Mo stainless steels, and B120VCA titanium alloy were tested in air, distilled water, tap water, 0.2% sodium dichromate solution, 1% marquench salt solution, 3% sodium chloride solution, trichloroethylene, cosmoline, 4% soluble oil solution, and high humidity.

Additional long-term testing of each alloy was initiated. Previous environmental stress-corrosion tests were terminated after 21 days, and the only alloy to fail after this period was the Vascojet 1000 steel. It is hoped that extended environmental stress-corrosion tests will indicate the relative susceptibility to stress-corrosion cracking of each alloy. Only the relatively severe environments of tap and distilled water were chosen, and the specimens were selected from the high-strength groups of each alloy. In addition, it is expected that the high-humidity tests will produce relatively rapid failures, so that the relative susceptibility to stress-corrosion cracking of each alloy may be more firmly established.

B. U-BEND SPECIMENS

Table 2 summarizes all of the U-bend stress-corrosion test data compiled to date. Three alloys are currently undergoing testing in eight different environments. U-bend specimens of Ladish D6AC, Type 300M, and Vascojet alloy steels are being tested in distilled water, tap water, 0.25% sodium dichromate solution, 1% marquench salt solution, 3% sodium chloride solution, trichloroethylene, cosmoline, and 4% soluble oil solution.

The test results reflect the cumulative effects of 72 days of testing. Failures were observed with each alloy in the environments of distilled water, tap water, salt water, and trichloroethylene. It is significant to note that in each case the Vascojet 1000 alloy showed the greatest susceptibility to stress-corrosion failure, while the Ladish D6AC alloy was the most resistant to stress-corrosion cracking.

III. FUTURE WORK

Data will continue to be accumulated on tests already in progress. Preparations are being made for fabricating welded test specimens with those alloys that appear to manifest the greatest resistance to stress-corrosion cracking. In addition, preparations for testing in the environments of high humidity and solid propellants are being made.

Alloy	Yield Strength 0.2% offset psi x 10³	Air: No. of Specimens	Air: Time to Failure (days)	Distilled Water: No. of Specimens	Distilled Water: Time to Failure (days)	Tap Water: No. of Specimens	Tap Water: Time to Failure (days)	0.25% $Na_2Cr_2O_7$ Soln.: No. of Specimens	0.25% $Na_2Cr_2O_7$ Soln.: Time to Failure (days)
Ladish D6AC	198.0	3	NF-25**	3	NF-21	3	NF-21	3	NF-21
	223.0	3	NF-25	3	NF-21	3	NF-21	3	NF-21
	235.0	6	NF-25	9	NF-21	9	NF-21	6	NF-21
	252.0	6	NF-25	9	NF-21	9	NF-21	6	NF-21
Type 300M	196.0	3	NF-25	3	NF-21	3	NF-21	3	NF-21
	213.0	3	NF-25	3	NF-21	3	NF-21	3	NF-21
	233.0	3	NF-25	5	NF-21	6	NF-21	3	NF-21
Vascojet 1000	194.0	3	NF-25	3	NF-21	3	NF-21	3	NF-21
	212.0	3	NF-25	3	NF-21	3	NF-21	3	NF-21
	258.0	3	NF-25	(1) (1) (1)	7.5 7.5 8.9	(1) (1) (1)	13.7 14.7 15.7	3	NF-21
	282.0	3	NF-25	(1) (1) (1)	1.5 3.2 4.3	(1) (1) (1)	2.7 8.8 9.7	3	NF-21
AM355	199.0(T)***	3	NF-49	3	NF-49	[illegible]	NF-49	3	NF-49
	250.0(L)	3	NF-25	6	NF-21	[illegible]	NF-21	3	NF-21
	275.0(L)	3	NF-25	5	NF-21	[illegible]	NF-21	3	NF-21
PH 15-7Mo	200.0	3	NF-25	3	NF-25	3	NF-25	3	NF-25
	225.0	3	NF-25	3	NF-25	3	NF-25	3	NF-25
	237.0	3	NF-25	3	NF-25	3	NF-25	3	NF-25
B120VCA Titanium	152.0	3	NF-25	3	NF-21	3	NF-21	3	NF-21
	140.0(T)	3	NF-25	3	NF-21	3	NF-21	3	NF-21
	146.0(T)	3	NF-25	3	NF-21	3	NF-21	3	NF-21
	140.0(L)	3	NF-25	3	NF-21	3	NF-21	3	NF-21
	158.0(L)	3	NF-25	3	NF-21	3	NF-21	3	NF-21
	166.0(T)	3	NF-25	3	NF-21	6	NF-21	3	NF-21

* Stressed to 75% of the 0.2% offset yield strength.
** NF-25 - No failure in 25 days.
*** L = Longitudinal, T = Transverse.

2

TABLE 1

[illegible] STRESS-CORROSION TEST DATA*

Environment													
3% $Na_2Cr_2O_7$ Soln.		1% Sherquench Salt Soln.		3% NaCl Soln.		Trichloroethylene		Gasoline		5% Soluble Oil Soln.		High Humidity	
No. of Specimens	Time to Failure (days)	No. of Specimens	Time to Failure (days)	No. of Specimens	Time to Failure (days)	No. of Specimens	Time to Failure (days)	No. of Specimens	Time to Failure (days)	No. of Specimens	Time to Failure (days)	No. of Specimens	Time to Failure (days)
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-87
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	{1 1 1	NF-87 57.0 61.7
6	NF-21	6	NF-21	6	NF-21	6	NF-21	6	NF-21	6	NF-21	{1 1 1	25.0 23.2 26.7
6	NF-21	6	NF-21	6	NF-21	6	NF-21	6	NF-21	6	NF-21	{1 1 1	5.7 7.0 14.2
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	-	—
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	-	—
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	-	—
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	-	—
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	-	—
3	NF-21	3	NF-21	{1 1 1	6.9 10.0 20.1	3	NF-21	3	NF-21	3	NF-21	-	—
3	NF-21	3	NF-21	{1 1 1	1.2 1.7 6.7	3	NF-21	3	NF-21	3	NF-21	-	—
3	NF-49	3	NF-49	3	NF-49	3	NF-49	3	NF-49	3	NF-49	-	—
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	-	—
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	-	—
3	NF-28	3	NF-28	3	NF-28	3	NF-28	3	NF-28	3	NF-28	3	NF-28
3	NF-28	3	NF-28	3	NF-28	3	NF-28	3	NF-28	3	NF-28	3	NF-28
3	NF-28	3	NF-28	3	NF-28	3	NF-28	3	NF-28	3	NF-28	3	NF-28
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	-	—
3	NF-21	3	NF-21	{1 1 1	NF-21 0.00 0.05	3	NF-21	3	NF-21	3	NF-21	-	—
3	NF-21	3	NF-21	3	NF-21	{2 1	NF-21 0.9	3	NF-21	3	NF-21	-	—
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	-	—
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	-	—
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	-	—

Alloy	Yield Strength 0.2% Offset psi x 10^{-3}	Distilled Water		Tap Water		0.25% $Na_2Cr_2O_7$ Soln.		1% Marq Salt S	
		No. of Specimens	Time to Failure (days)	No. of Specimens	Time to Failure (days)	No. of Specimens	Time to Failure (days)	No. of Specimens	No. of Specimens
Ledish D6AC	196.0	2	NF-72*	2	NF-72	2	NF-72	2	2
	223.0	2	NF-72	2	NF-72	2	NF-72	2	2
	235.0	2	20.2 32.9	2	NF-72 33.3	2	NF-72	2	2
	252.0	2	16.4 22.4	2	25.9 34.9	2	NF-72	2	2
Type 304N	196.0	2	NF-72	2	NF-72	2	NF-72	2	2
	213.0	2	16.4 34.9	2	NF-72	2	NF-72	2	2
	233.0	2	14.9 34.9	2	22.4 29.1	2	NF-72	2	2
Vascojet 1000	194.0	2	NF-72	2	NF-72	2	NF-72	2	2
	212.0	2	NF-72 14.7	2	60.4 69.4	2	NF-72	2	2
	240.0	2	4.4 11.4	2	7.4 19.5	2	NF-72	2	2

*NF-72 = No failure in 72 days.

TABLE 2

U-BEND STRESS-CORROSION TEST DATA

Environment												
Cr_2O_7 Soln.	1% Harpoon Salt Soln.		3% NaCl Soln.		Trichloroethylene		Gasoline		1% Soluble Oil		1% Soluble Oil Soln.	
Time to Failure (days)	No. of Specimens	Time to Failure (days)	No. of Specimens	Time to Failure (days)	No. of Specimens	Time to Failure (days)	No. of Specimens	Time to Failure (days)	No. of Specimens	Ti Fa (d	No. of Specimens	Time to Failure (days)
XF-72	2	XF-72	2	XF-72	2	XF-72	2	XF-72	2	X	2	XF-72
XF-72	2	XF-72	2	XF-72	2	XF-72	2	XF-72	2	X	2	XF-72
XF-72	2	XF-72	1	XF-72	2	XF-72	2	XF-72	2	X	2	XF-72
			1	62.4								
XF-72	1	XF-72	1	16.5	1	XF-72	2	XF-72	2	X	2	XF-72
					1	36.9						
XF-72	2	XF-72	2	XF-72	2	XF-72	2	XF-72	2	X	2	XF-72
XF-72	2	XF-72	1	11.3	1	49.9	2	XF-72	2	X	2	XF-72
			1	40.9	1	56.1						
XF-72	2	XF-72	1	11.3	2	XF-72	2	XF-72	2	X	2	XF-72
			1	25.3								
XF-72	2	XF-72	1	XF-72	2	XF-72	2	XF-72	2	X	2	XF-72
			1	49.9								
XF-72	2	XF-72	1	13.7	2	XF-72	2	XF-72	2	X	2	XF-72
			1	53.3								
XF-72	2	XF-72	1	4.3	1	36.9	2	XF-72	2	X	2	XF-72
			1	6.3	1	36.9						